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Effective governance of natural resources is a key challenge facing many developing nations. There is general agreement that without effective institutions, resources will be underprovided and overused. What is less certain, however, is what these institutions might be and who ought to provide them. Should governments take the lead in supplying institutions and organizing collective action, should this task be resolved through market forces, or should resource users of a “common pool resource” be encouraged to take the lead? This paper presents the view that it is difficult for external actors to design optimal institutions and enforce rules at low cost because solutions tend to be conditional and situation specific. Therefore, local resource users are better equipped to develop or be major participants in developing institutional solutions. Support for this idea is drawn from empirical studies of irrigation systems in Nepal. Comparisons of the performance of farmer-managed irrigation systems with that of agency-managed irrigation systems show that the former consistently outperform the latter on most performance measures. This paper offers two key insights: developing effective institutions is as important as developing physical infrastructure and local resource users may be able to offer better institutional solutions under certain conditions than government agencies when resources are local in scale.

Key words: Irrigation, Governance, Common pool resource, Collective action, Natural resource management

Introduction

Effective governance of irrigation systems is crucial to Nepal, which has predominantly an agrarian economy that is dependent on irrigated paddy cultivation to feed a growing population. Year-round irrigation is available for less than 20% of the 2.2 million hectares of land area that could be irrigated (Shah and Singh, 2001), and therefore more effective irrigation could greatly expand agricultural production, which currently contributes 38% of the gross domestic product (Ministry of Finance, 2006). While there is no dispute in recognizing the importance of irrigation, there are intense disagreements over how irrigation infrastructure ought to be developed and governed. Some believe that governments are necessary in order to supply and organize collective action, while others believe that this task is best done by self-governed resource

users.

The Nepali State's involvement in the provision of irrigation infrastructure has been substantial. However, the performance of agency-managed irrigation systems (AMIS) is unsatisfactory relative to the resources invested in the sector (NPC, 1994). Failure to provide an assured supply of water, to get water to farmers at the tail end, and to achieve economies of scale in construction, operation, and maintenance are among the most consistently cited problems. Interestingly, many of these problems observed in AMIS are a result of poorly designed institutions i.e. rules in use rather than of poorly designed infrastructure.

Farmer-managed irrigation systems (FMIS), in contrast, are reported to perform relatively well (Lam, 1998). In a systematic study, Lam showed that FMIS outperformed AMIS on most key parameters — agricultural yield, cropping intensities,

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and ability to get water to the tail end. The potential of FMIS is no doubt substantial, but not every FMIS is successful. There are some settings where appropriators are able to self-organize successfully and other settings where they are not. Since many variables can jointly affect the benefits and costs of organization, predicting the emergence or lack of self-organization simply by looking at the presence or absence of a set of resources and user attributes is not a trivial task (Ostrom, 2001). This paper examines some of the attributes of and resource settings in FMIS in Nepal to explain how they have influenced the ability of farm communities to self-organize. Such an explanation should allow for the design of policies that can strengthen institutional and governance capabilities of FMIS.

The paper is organized into five parts. Part I presents an overview of the irrigation sector and its performance in Nepal. Part II explores the incentive structures facing farmers in self-organized versus agency-managed systems and examines why farmers in the former systems may be better motivated than those in the latter. Part III compares the performance of AMIS and FMIS. Part IV presents research results and explores how some of the attributes of resource users, attributes of physical resources, and resource setting can affect cooperation and performance in self-organized systems. The conclusions and lessons that can be learned to improve irrigation performance are then presented at the end in Part V.

Irrigation Development and Planning in Nepal

Nepal has a total cultivated area of 2.6 million hectares. Although 85% of this area has potential for irrigated agriculture, only 1.1 million hectares (42%) is covered by irrigation infrastructure (Shah and Singh, 2001; NENCID, 2007). Surface water is used to irrigate 900,000 ha and groundwater (mainly in Terai) to irrigate 200,000 ha. Year-round irrigation is available to only 38% of the irrigated areas. Most (75%) of the irrigated areas are serviced by FMIS and the remaining (25%) by AMIS (NENCID, 2007).

The vast majority of the irrigation infrastructure developed until the mid-1950s was constructed and managed by farmers. During this period, there was

some state involvement but it was limited (Shah and Singh, 2001). Chandra and Juddha Nahars (canals) were among the first public sector irrigation projects undertaken by the national government in 1923 and 1946, respectively. State budgets were also allocated to construct and maintain a few *raj kulos* or royal canals (Regmi, 1978). It was only after 1956 that planned modes of irrigation development were initiated by the Government through its five-year plans. Despite government involvement, even today, FMIS contribute three times as much toward irrigated agriculture than do AMIS.

Irrigation infrastructure development from 1956 to 1980 initially focused on the construction of medium- and large-scale projects. It then gradually moved toward the intensification of existing command areas through the expansion and rehabilitation of existing infrastructure. Program implementation during this period was very centralized. Irrigation officials assumed all planning, construction, operation and management, and maintenance responsibilities. Beneficiaries were not involved. Only after 1985 did the government begin to take a more integrated approach to developing land and water resources, and, unlike earlier times, more emphasis began to be placed by Government on user involvement in the irrigation process (Shah and Singh, 2001; Angood *et al.*, 2002).

The policy reforms undertaken by Government to adopt a participatory approach to irrigation development are reflected in documents such as the *Water Resources Act 1992* and the updated *Irrigation Policy 2003* (Water Aid Nepal 2005). The policy sets out objectives and guidelines for irrigation interventions, including FMIS development and management and transfer of Department of Irrigation (DOI)-constructed systems to water user associations (WUAs) (Water Aid Nepal, 2005). The irrigation policy, which was initially adopted in 1992, has explicit provisions for supporting community efforts in irrigation development and for encouraging more user participation in agency-led irrigation development programs. The *Water Resources Act 1992* also provides a legal basis for implementing participatory development programs as it recognizes the rights of WUAs. Another important document is the Government's 20-year (1995–2015) *Agricultural Perspective Plan* (NPC,

1995), which identifies irrigation as the primary input for increasing agricultural productivity and recognizes FMIS as a key vehicle for delivering the input.

Irrigation Performance

An estimated US\$1.2 billion was spent in the irrigation sector from 1956 to 2000 (Shah and Singh, 2001). Only 20% of this amount was funded through the government's resources; the remaining 80% was funded by external donors. The Asian Development Bank, World Bank, and Saudi Development Fund were the major donor agencies. Nearly 60% of these funds were spent on constructing new irrigation infrastructure. Despite a standing policy since the mid-1980s to prioritize the rehabilitation and expansion of FMIS networks, the DOI has invested only about 16% in this area (Shah and Singh, 2001).

DOI investments in medium- and large-scale projects have been disappointing. Shah and Singh (2001) reported that water volumes supplied by many large projects such as Sunsari-Morang, Bagmati, and Narayani are far below original plans, and the projects consistently have capital cost over-runs. Some projects, such as Bagmati and Babai, are reported to have cost over \$5,000/ha to construct. The 1994 appraisal by the National Planning Commission of irrigation development performance in the country was also negative, reporting "irrigation development and operation in Nepal is performing dismally relative to the amount of resources poured into the sector" (NPC, 1994). There are many reasons for such poor performance, but the ones that are more frequently reported are (a) weak governance framework and weak enforcement in attaining effective service delivery; (b) unrealistic productivity projections in assessing benefit-cost ratios; (c) poor system management; (d) insufficient operation and management due to lack of user participation; and (e) poor understanding of farmer priorities (ADB, 2001). The institutional arrangements to induce realistic project planning and effective system management are, obviously, weak.

Intervention by government agencies to improve FMIS has also run into difficulties. Ostrom (1992, 2002) pointed out that these difficulties often arise because irrigation agencies fail to recognize the

institutional aspect of irrigation systems and focus only on improving physical capital. To emphasize her point, Ostrom cited the experience of the USAID-funded Chiregad Irrigation Project in Dang, as reported by Hilton (2002). A new irrigation system with permanent headworks and cement-lined canals was constructed in an area that was previously irrigated by five FMIS. Making no effort to understand how the pre-existing water associations were organized, DOI appointed a new user committee that failed to include any of the water managers of the five FMIS. The outcome of this intervention was that only three of the five *maujas* (villages) received water consistently. Prior to the intervention, all five *maujas* used to receive adequate water. The effort to improve agricultural productivity through investments in physical capital alone thus resulted in reduction of the service area, unreliable water delivery, a non-functional WUA, and a weakened older WUA. Institutional structures stand on social capital developed over many years of learning through shared experiences and are as real as physical capital. Their neglect, as we see in this example, not only resulted in weakening of farmer organizations but also led to adverse outcomes.

Motivation to Self-organize — FMIS versus AMIS

A self-organized system can be structurally better at generating positive incentives than externally organized systems. In a self-organized system, such as the FMIS, the farmers collectively construct and govern their own systems. They make decisions on delineating service areas, determining water allocation rules, and assigning maintenance responsibilities. In externally designed systems, such as the AMIS, someone other than the farmers designs the physical system and assumes responsibility for making rules and enforcing them. Government officials who are tasked with managing these systems, however, have to govern on shoestring budgets and with limited manpower. Without much incentive to develop long-term working relationships with the farmers and faced with resource constraints, many try to develop simple uniform allocation rules across the board and often neglect to enforce them. Given the farmers' diverse cropping schedules and needs,

such uniform rules are mostly inadequate, and, without enforcement, the stage is set for breaking rules. When “official rules” do not match local needs, then conflicts break out, canals are breached, and physical capital is destroyed (Lam, 1998).

In more recent times irrigation policy has encouraged “turnover” and “joint management” of AMIS to formal WUAs to improve irrigation operations (Shivakoti and Ostrom, 2002). However, very little attention tends to be given by government officials in forming strong WUAs, and these associations are often seen as arrangements by them to obtain a community’s cooperation. Little is done to either encourage or develop the governing function of these organizations. Officials (professional engineers) who oversee this process are not motivated and often not skilled to serve the needs of the farmers. Engineers are more interested in the construction part of the process rather than in the operation and management function. And, institutional aspects of irrigation system design are often his/her weak point as it is not a strong component of engineering training. The farmers, too, are not confident about the transfer process and are unwilling to invest their time in operating the system. A tendency to shirk on the part of the officials as well as a tendency to free-ride on the part of the farmers often results in the poor performance of AMIS.

Farmers in successful FMIS tend to overcome their collective action problems by crafting their own rules (Ostrom, 1992; Shivakoti and Ostrom, 2002). The conditions that are necessary to initiate collective action, however, do not arise spontaneously. Unless farmers have a common shared understanding of the costs and benefits of engaging in collective action, unless a secure property agreement regime makes it possible for them to reap the benefits of their efforts in the long run, and unless they are confident that external authorities will not interfere in their rule making, implementation, and enforcement activities, farmers will not invest their efforts in organizing for the long term. Simply turning over systems to the farmers and expecting viable organizations to take root is expecting too much. To craft rules that suit a particular environment, there has to be an understanding of the inter-relationships between the rules and the physical, social, and cultural environments.

Comparing FMIS and AMIS Performance

There are many individual case study reports by authors who assert that FMIS in Nepal perform better than AMIS. Lam (1998) undertook a systematic and comprehensive study of 127 Nepali irrigation systems and reached the same conclusion. In the following sections, I review his results and those of a few others to underscore Ostrom’s (1990) idea that self-organized resource users may be better able to resolve cooperation dilemmas (or be a major part in their resolution) when resources are local in scale. In other words, external actors may face more difficulties than local resource users in designing optimal institutional solutions and enforcing rules at lower cost.

Lam used three measures of irrigation performance — agricultural productivity, water delivery, and physical condition — to compare performance between FMIS and AMIS. All of his measures are composite indices derived from multiple variables. Agricultural productivity attempts to capture the productive potential of a group resulting from their collective action efforts. Water delivery measures the ability of a system to deliver water adequately, reliably, and equitably. Physical condition is a measure of how well an irrigation system is being maintained. Comparing FMIS and AMIS along each of these three dimensions, Lam found that FMIS, on average, had higher levels of agricultural productivity, maintained their infrastructures better, and delivered water more effectively than AMIS. These differences are statistically significant.

Two other relevant results that Lam reported are that rule following among appropriators is significantly greater in FMIS than AMIS, and levels of mutual trust are higher in FMIS. More than 50% of the FMIS are characterized by high levels of rule following, but only 20% of AMIS; rule infractions are of a minor nature in 9 out of 10 FMIS but in 5 out of 10 AMIS; and farmers trust fellow farmers nearly twice as much in FMIS than in AMIS. The reason why FMIS are able to perform better than AMIS is probably because the rules adopted by the former are better able to distribute the benefits and costs more equitably among the users than the latter. This is reflected in the higher levels of trust and greater rule-following behavior observed in

FMIS than in AMIS.

Another study by Ostrom and Gardner (1993), based on large number of cases, also suggested that FMIS are better able to deliver water to their tail ends than AMIS. Water is generally most abundant in river courses during the monsoon season. In spring and winter, however, water tends to be scarcer. Water is the most critical agricultural input for Nepali farmlands, and crop yields and cropping intensities are mostly a function of its availability. Therefore, the ability of irrigation systems to deliver water to their tail ends across the seasons is a strong indicator of irrigation performance. Comparing FMIS and AMIS on this measure, Ostrom and Gardner (1993) found that FMIS consistently outperforms AMIS across the seasons. Their results show that three times as many FMIS were able to provide abundant water to their tail ends than were AMIS during winter and spring.

Studies of 160 FMIS in Tanahu (Poudel *et al.*, 1994) and of 88 FMIS in Chitwan (Shukla *et al.*, 1993) also indicated that FMIS are able to produce more spring paddy rice (4 t/ha/y and 4.6 t/ha/y, respectively) than the national average (2.28 t/ha/y).

The above results indicate that farmers in self-organized irrigation systems are capable of performing better than their counterparts in externally managed systems. This does not mean, however, that farmers are always successful at self-organization. There is general agreement among common pool resource scholars that appropriators who are dependent on a resource, intend to use their resources over a long time, have achieved certain levels of trust, and possess some level of autonomy to make their own rules are more likely to self-organize (Ostrom *et al.*, 1994; Bromley, 1992; McCay and Acheson, 1987). Whether they are actually able to do so, however, depends on how attributes of the resource and attributes of the users interact in specific field settings to affect the perceived costs and benefits of organizing (Ostrom, 1999). In the following section, I examine how some of the resource attributes and resource user attributes may influence the performance of FMIS in specific resource settings.

FMIS Performance in Chitwan — Research Results

This section draws heavily on a study of 74 FMIS in Chitwan, Nepal (Regmi, 2007). In Chitwan, there are two distinct types of river systems: north-south (N-S) and east-west (E-W) flowing. Rivers that flow N-S originate from the Mahabharat Hills and pass through changing terrain from hills to plains. These rivers are characterized by steep gradients, seasonal flows, changing course, low-discharge volumes, and difficult terrain (Pradhan, 1989). Irrigation systems drawing water from these rivers tend to have longer canals, pass through landslide zones, and require frequent maintenance of diversion structures. E-W rivers, on the other hand, are characterized by flat terrain, mild gradients, perennial flows, and high discharge volumes. Irrigation systems on these rivers enjoy an advantage over the other systems in the ease with which appropriators can draw water. The N-S and E-W groupings reflect distinct resource settings. In addition, system variations occur with respect to group size, ethnic composition, exit options, in-group income differences, and many other variables. Within this context, local resource users have to organize and craft rules that allow them to maintain their resources and ensure equitable resource distribution.

Performance of an FMIS in Chitwan tends to be strongly associated with the orientation of the river system from which it draws its water. As pointed out above, the characteristics of a river system have a direct bearing on the amount of effort required to operate and maintain a system and the volume of resource available. This is reflected in the ability of E-W irrigation systems to draw water for more months in a year, maintain their infrastructures better, and enjoy higher cropping intensities. Whereas all E-W irrigation systems are able to take water for more than 9 months of the year, only one out of four N-S systems are able to do this. Also, agricultural productivity and infrastructure in E-W systems are better than those in N-S systems by factors of 1.25 and 1.18, respectively.

The above results, however, do not necessarily mean that E-W systems are better governed than N-S systems. In fact, higher levels of rule-following behavior are observed in N-S systems than in E-W

systems, and the differences are significant ($\chi^2=3.185$, $P=0.074$). This suggests that less-well-endowed resource systems (N-S) may be more rigorous at fine-tuning operational rules and following them than their better-endowed counterparts. The larger implication of this result, though, is associated with self-organization. Resource users, even in the absence of a conducive environment, may be able to self-organize and develop effective agreements when the benefits of organizing are commonly understood.

Irrigation performance was also found to be influenced by the willingness of individuals in groups to assume leadership or entrepreneurial activities and a group's history of prior organizational experiences. One in five E-W systems reported weak leadership roles versus three in five N-S systems. Similarly, some history of cooperation in activities other than irrigation was reported in eight of ten E-W systems versus three of ten N-S systems. These differences in leadership and organizational activities associate positively and significantly with irrigation performance. Unless individuals are willing to invest substantial amounts of their personal time and energy in coordinating activities of the many users, it may not be possible to craft workable institutions. Making, testing, fine-tuning, interpreting, and monitoring and enforcing rules to structure irrigation activities is a continuous process and requires substantial amounts time and energy. Ternström (2002) also reported a significant relationship between leadership abilities and performance in her study of irrigation systems. Any type of prior organizational history is important. Familiarity with various rules and strategies used to achieve various forms of regulations make the task of organization a bit easier, as users are more likely to agree upon rules whose operation they understand from prior experience.

Results from Chitwan also indicate that there is no correlation between socio—cultural differences as reflected by a group's ethnic composition and irrigation performance; a negative correlation between income variation and performance; and no correlation between the size of an irrigation system as measured by its command area and performance. The results suggest that variations in income within groups may be a greater impediment to self-organization than the number of ethnicities

that comprise a group. The socio—cultural result is in line with the studies of Fujita *et al.* (2000), Gautam (2002), and Somanathan *et al.* (2002): they too did not find any association between their measures of socio-cultural heterogeneity and collective action. The results in income variation and size are similar to those of Tang (1992), Lam (1998), and Ternström (2002): a negative correlation between income inequality and collective action and no correlation between size and collective activity. One might expect better coordination and collective action when system size is small, but this appears not to be the case.

The effects of engineering infrastructure — i.e., the type of headwork or canal lining — on irrigation performance appear not to be uniform. The presence of a sturdier and more permanent type of headwork on a system appears to be negatively correlated with performance. A sturdier cement-lined canal, on the other hand, is positively correlated with system performance. Although the results are not statistically significant, their implications very much are. A truly permanent headwork, ironically, generates disincentives for head enders to cooperate with tail-enders in system maintenance (Lam, 1998). Partial or complete cement lining, on the other hand, appears to improve performance by minimizing water losses, thereby enabling water to reach the tail ends. The policy implications of such results are that improvements in engineering infrastructure alone may not necessarily translate into improved system performance. Unless users are able to craft and enforce rules that can cope with the asymmetries generated by improvements in irrigation infrastructure, the positive effects may well be cancelled out by the negative effects.

Conclusion

Irrigation systems face a variety of challenges. The terrain can be difficult, rivers can be unruly, group members may belong to diverse cultural backgrounds, group sizes can vary, asset endowments may differ, and interests may differ within groups. Given these constraints, an irrigation system has to be able to solve the fundamental problems of provisioning and appropriation associated with common pool resources. Intakes and canals have to be constructed and maintained regularly, and working rules have to be crafted to reflect

appropriation rights and responsibilities. Such activities, which consume lots of energy and require the mobilization of significant resources, might be undertaken more effectively by self-governed groups than by centralized government agencies.

The arguments for government interventions are often based on the premises that flimsy infrastructures used by farmers result in waste, group differences within a community prevent farmers from self-organizing, increasing group sizes and command areas make it more difficult for farmers to reach effective agreements among themselves, and larger integrated systems result in economies of scale. Empirical results from the field, however, suggest otherwise. Despite considerable group heterogeneity, farmers are able to organize; even with flimsy infrastructure, they are able to outperform AMIS with superior infrastructure; and they are able to reach agreements even when group size or command area is large. These results underscore Oström's (2002, 2005) observation that there is a strong institutional aspect to irrigation systems, and focusing only on improving physical capital may not result in improved irrigation performance.

Although FMIS potential may be substantial, not every FMIS is successful. Some resource settings tend to be more conducive to self-organization than others. Systems with difficult topography — N-S systems — face far more organizational challenges than systems with favorable topography. However, the abilities of groups to craft rules and their willingness to monitor and enforce them can, to a great extent, overcome the problems associated with initial resource endowments. The lack of leadership abilities or prior organizational history, in fact, can turn out to be more detrimental to self-organization and irrigation performance than poor initial resource endowments, ethnic differences, or even the presence of permanent irrigation infrastructure. Understanding how different variables interact in different settings can help in designing policies that can strengthen institutional and governance capabilities of FMIS.

There are many dimensions to the basis for cooperation among individuals. Individual common-pool resource users are likely to contribute and cooperate only if they perceive that they will be able to reap the long-term benefits of engaging in collective action. They are also more likely to cooperate

if they are aware of their interdependence and see mutual benefits resulting from working together. The presence of a set of credible, commonly understood, well-enforced, and agreed-upon rules further helps in generating a positive incentive system for villagers to engage in collective action. Without creating the right environment, bureaucracies cannot assume that cooperation among resource users will develop naturally once an irrigation system has been handed over to them. Creating the right environment requires bureaucracy to emphasize institution building, engage local resource users in all aspects of irrigation development, and ensure their legal standing. Common pool resource systems are coproduction processes that perform best when both the oversight agencies and resource users cooperate in making the system work.

Farmers in Chitwan have been able to overcome collective action problems and are fairly successful at managing water resources in their unique settings. This implies that, even though it is difficult, it is possible for resource users with a supportive political system to locally overcome what are assumed to be severe collective-action problems. If external assistance is geared toward supporting the farmers' efforts to develop their own institutions, this could result in enhanced water security and improved irrigation performance.

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